

There Has Never Been a Better Time or a Greater Need for Resistance Management*

Paul K. Leonard

Cyanamid International, Chaussée de Tirlemont 105, B-5030 Gembloux, Belgium

(Revised version received 14 June 1997; accepted 16 July 1997)

Abstract: Integrated pest management (IPM) and sustainable agriculture benefit from selective and environmentally benign crop-protection products. The performance of these products, however, is threatened by resistance. If it is to be prevented from standing in the path of progress, resistance must be managed. As agricultural practices move towards IPM and sustainable crop protection, selection pressure will be concentrated on products which are compatible with these systems. Producers, researchers, government and extension workers cannot solve these complex problems alone. The key to success is collaboration. The Insecticide Resistance Action Committee (IRAC) was set up by the crop-protection industry in 1984 to promote and co-ordinate its contribution to resistance management. Today, it is collaborating with research institutes, government organisations and extension services to combat resistance. IRAC focuses on research and communication projects which reduce selection pressure, organising workshops in 'resistance hot spots' and providing input to draft legislation. Selected examples of IRAC's collaborative work are described.

Pestic. Sci., **51**, 387–390, 1997

No. of Figures: 0. No. of Tables: 0. No. of Refs: 12

Key words: resistance management, IRAC, IPM, crop-protection industry

1 INTRODUCTION

In 1984, the threat of insecticide and acaricide resistance development was well known. The scientific literature on resistance was abundant. There was, however, no collective forum for addressing this problem within the crop-protection industry. As a result, meaningful collaboration was difficult.

Substantial progress has been made over the last decade. Today, the situation is quite different. Producers, academics, advisers, distributors and farmers are working together to reduce the threat of resistance.

This paper documents some of the many ways in which industry, through the Insecticide Resistance

Action Committee (IRAC),¹ is bringing together those who share the objective of managing resistance. In particular, it provides an insight into the ways in which IRAC will focus its resources over the next five years.

2 THE NEW URGENCY FOR RESISTANCE MANAGEMENT

Integrated pest management (IPM) and sustainable agriculture rely, to a greater or lesser extent, on a limited spectrum of the most selective and environmentally benign crop-protection products. The performance of these products, however, is threatened by resistance. As the move towards IPM and sustainable crop protection continues, selection pressure will be increasingly concentrated on these products. The recent development of resistance by codling moth (*Cydia pomonella* L.) to widely used insecticides in the south-east of France^{2–4} provides an example of how resistance can limit product choice and threaten the future of

* Based on a presentation at the Conference 'Resistance '97—Integrated Approach to Combating Resistance' organised by the Institute of Arable Crops Research in collaboration with the SCI Pesticides Group and the British Crop Protection Council and held at Harpenden, Herts, UK on 14–16 April 1997.

IPM. As codling moth became increasingly resistant to selective products like phosalone and diflubenzuron, growers turned to various combinations of broad-spectrum organophosphates for acceptable pest control. However, by doing this, IPM practices were compromised.

To prevent resistance from standing in the path of progress in this way, it must be managed. Those who determine product use patterns must recognise the risks posed by resistance and work together to maintain the benefits that environmentally selective crop-protection products provide.

3 MEETING THE CHALLENGE THROUGH COLLABORATION

Collaboration is the key to success. IRAC was formed in 1984 because the crop-protection industry recognised a need for co-operation to combat resistance problems. For example, the spirit of co-operation that was created enabled IRAC to broker an historic initiative with the development of four new acaricides in 1994 (see below).

To illustrate IRAC's collaborative approach to resistance management, three areas of activity are outlined below:

3.1 Prevention of acaricide resistance

Although there were marked differences in their chemical structures, four novel acaricides—tebufenpyrad, fenazaquin, fenpyroximate and pyridaben—appeared to share a mode of action. In-house research and contemporary publications indicated that these compounds acted at the same rotenone site in the mitochondrial electron-transport chain.^{5–9} With a long history of resistance development, the potential for spider mites to develop cross-resistance to these mitochondrial electron-transport inhibitors (METIs) was recognised.

No one company involved with these compounds could tackle this alone. What was needed was a common resistance management strategy for all four compounds. IRAC responded to this challenge by recommending a radical solution. Member companies agreed to limit applications to one METI application per location in any one year. In order to gain maximum compliance, it was agreed that competitor products should be referred to by name on each other's labels. Having agreed the strategy, the next challenge was to communicate it in a way that made a difference. The strategy was published at the Brighton Crop Protection Conference in 1994.¹⁰

To build on this recommendation, the Institute of Arable Crops Research at Rothamsted in England was commissioned to develop and validate a resistance monitoring method and quantify baseline responses.

With a rapid bioassay method now in place for three of the four METI compounds, we are well placed to react should resistance development be suspected in Europe.

This unprecedented level of inter-company co-operation was made possible by IRAC, and provides an important benchmark in the history of resistance management, as it was in place before resistance had developed in Europe.

3.2 The risk of malaria being transmitted by resistant mosquitoes

For decades there has been little evidence that resistance development by malaria-carrying mosquitoes can be managed. This has resulted in a lack of agreement as to how best to manage this important threat to human welfare. This challenge is now being addressed through a project jointly funded by insecticide manufacturers from Europe, Japan and the USA, with IRAC providing additional financial support. A large-scale resistance management programme is now in progress in Chiapas, Southern Mexico. Baseline sensitivities of the malaria vector *Anopheles albimanus* Weid. are being measured by bioassay and biochemical assays as part of a three-year laboratory and field programme.¹¹ The aim of the study is to compare development of resistance in isolated populations subjected to varying treatment regimes. The response of these populations will provide a unique insight into how best to develop and monitor resistance management strategies for malaria vector control.

The initiative draws together expertise and resources from insecticide manufacturers, the World Health Organisation (WHO), Centro De Investigacion De Paludismo in Mexico, the University of Wales and IRAC's Public Health and Vectors Working Group. IRAC created the environment that made such global collaboration a reality.

3.3 Communication of the need to manage resistance

Unless growers and pest-control operators can be persuaded to change the ways in which they select and use agrochemical products, resistance management will not succeed. Mindful of this, IRAC has carefully evaluated the way in which it communicates with such people. An analysis of the distribution of IRAC's financial support demonstrated that a disproportionate effort was being placed on research projects and too little effort was focused on communicating resistance management guidelines.⁵ It became apparent that IRAC's traditional means of communicating, *via* scientific and industrial publications, was not effective. A new way of reaching people on the front line of resistance management, i.e. growers and advisers, had to be identified.

In order to render the technical language used by resistance researchers more accessible to non-scientific personnel, IRAC enlisted the assistance of Fleishman-Hillard, a leading public relations company in the USA which specialises in communicating with growers and distributors. This collaboration resulted in the production and distribution of thousands of posters and leaflets highlighting the problem, with practical advice on how to limit resistance development. The leaflet features the slogan, 'There's only one alternative to resistance management—resistance management is up to you'. It aims to provide practical advice on the nature of resistance and how it may be avoided. In order to reach the widest possible audience, it is being translated into a range of languages for distribution around the world. In addition, an education pack including 35-mm slides and video presentations will be made available. IRAC is currently considering how best to disseminate this material.

IRAC has recognised the need to address its message to a wide range of people at all levels throughout the agrochemical community. Its Communications Working Group is actively pursuing a range of communication initiatives including:

- (i) sponsorship of the Resistant Pest Management Newsletter (edited by Michigan State University), which is received by 2600 researchers, advisers and Government workers around the world;
- (ii) ensuring effective communication within the Industry. IRAC's members include the world's leading manufacturers of crop-protection products. Each company representative is charged with promoting resistance management in his or her own organisation. In particular, we target those developing product-use patterns;
- (iii) publication of the results of IRAC's world-wide resistance survey.¹²

4 FUTURE FOCUS AND PRIORITIES

IRAC's continued success depends on its ability to focus. With a seemingly endless spectrum of actual or potential cases of resistance to work on, IRAC must concentrate on activities which will have the greatest impact. Over the next five years, IRAC plans to concentrate its resources in the following areas:

4.1 Resistance management guidelines

IRAC has developed a series of resistance management guidelines. These are intended to be used as a basis for more specific strategies to suit individual cropping systems. They will be published through leading national and international journals. IRAC is also working

with the Global Crop Protection Federation (GCPF) to make these guidelines and other up-to-date information available *via* a home page on the Internet.

4.2 Workshops in resistance 'hot spots'

There are recognised locations, known as 'hot spots', where resistance develops rapidly and considerably shortens product life. IRAC is in the process of setting up workshops in such locations in collaboration with local universities and extension services to reduce this product wastage. For example, IRAC's Fruit Crops Working Group convened a workshop in Lérida, Spain where the European red spider mite (*Panonychus ulmi* Koch) rapidly developed resistance to clofentezine and hexythiazox. With the recent introduction of METI acaricides in this area, it is the right time to ensure that the need for resistance management is understood by all.

4.3 Continued support of resistance management and IRAC activities

Resistance management is like any other commercial activity. It requires expertise, time and investment. In the case of IRAC, member companies contribute about US \$90 000 per annum through subscriptions. However, the greatest contribution is made in kind through time spent on IRAC projects. Results need to be clearly visible for companies to justify their continued support of IRAC and resistance management. This means that IRAC must promote its activities and collaborations so that its success is recognised. The GCPF home page is one of the ways in which this will be done.

4.4 Assessing the risk posed by resistance

Based on its knowledge of the compounds, their use patterns and biochemistry, the crop-protection industry, through IRAC, is ideally placed to assess the risk posed by resistance to insecticides and acaricides. With a massive investment in research and development, agrochemical producers cannot afford to ignore this risk. Equipped with this knowledge, IRAC has the motivation, means and commitment to tackle this problem head-on. The examples above provide evidence of this.

IRAC does not regard legislation as the most appropriate tool for resistance management, but is, however, keen to offer expert advice if legislation is to be drafted. With a wealth of experience built up over more than a decade, IRAC is uniquely qualified to provide advice on the practicality and likely impact of draft legislation.

5 SPONSORSHIP

Ultimately, resistance management is only effective if it results in reduced selection pressure. Resistance management activities which do not in some way reduce selection of resistance genes are not worth supporting.

In future, proposals for IRAC funding will be evaluated on their ability to reduce selection pressure. Those proposals that are likely to result in the greatest reduction in selection pressure will receive the highest priority for funding. The current round of IRAC funding will be complete at the end of 1997, so that funds will therefore be available for new collaborative projects from 1998 onwards.

6 CONCLUSIONS

The crop-protection industry is aware of the risks posed by resistance and is ready to play its part in meeting this challenge. Through having a common objective and by working together, it has been possible to make substantial progress in the struggle to combat resistance. The industry is keen to work, through IRAC, with organisations and individuals sharing the objective of resistance management. It is essential that this progress is consolidated and that we continue to take strength in our efforts to tackle resistance.

REFERENCES

1. Jackson, G. J., Insecticide resistance: what is industry doing about it? *Proc. Brit. Crop Prot. Conf.—Pests and Diseases*, **2** (1986) 943–9.
2. Bouvier, J. C., Brosse, V. & Sauphanor, B., Insecticides, la résistance du Carpocapse. *L'arboriculture fruitière*, **497** (1995) 21–3.
3. Malézieux, S., Speich, P. & Martinet, C., Le Carpocapse des pommes dans le sud-est de la France: Un cas complexe de résistance aux insecticides. *Phytoma-LDV*, **471** (1995) 18–21.
4. Sauphanor, B., Benoit, M., Bouvier, J.-C., Perron, G., Malézieux, S. & Frémond, J.-C., Un cas de résistance du Carpocapse des pommes au diflubenzuron dans le sud-est de la France. *Phytoma LDV*, **458** (1994) 46–9.
5. Leonard, P. K. & Perrin, R. M., Resistance management—Making it happen. *Proc. Brighton Crop Prot. Conf.—Pests and Diseases*, (1994) 969–72.
6. Hollingworth, R. M., Ahammadasahib, K. I., Gadelhak, G. G. & McLaughlin, J. L., Complex 1 of the mitochondrial respiratory chain, a target for pesticide development by both man and nature. *Abstract papers of American Chemical Society*, Vol 203 No. AGRO156 (1992) 1–3.
7. Hollingworth, R. M., Ahammadasahib, K. I., Gadelhak, G. G. & McLaughlin, J. L., New inhibitors of complex I of the mitochondrial respiratory chain with activity as pesticides. 648th meeting of the Biochemical Society, Belfast, N. Ireland, UK 14–17 September 1993. *Biochem. Trans.*, **22** (1993) 230–3.
8. Motoba, K., Suzuki, T. & Uchida, M., Effect of a new acaricide, fenpyroximate, on energy metabolism and mitochondrial morphology in adult female *Tetranychus urticae*. *Pestic. Biochem. Physiol.*, **43** (1992) 37–44.
9. Anon, New miticide from Cyanamid. *Chemistry in Britain*, Jan. 1993, p. 17.
10. Wege, P. J. & Leonard, P. K., Insecticide Resistance Action Committee (IRAC) fruit crops spider mite resistance management guidelines 1994. *Proc. Brighton Crop Prot. Conf.—Pests and Diseases*, **4** (1994) 427–30.
11. Penilla, R., Rodriguez, A. D., Hemingway, J., Estrada, J. L. T., Jimenez, J. I. A. & Rodriguez, M. H., Rotational and mosaic strategies for delaying the development of insecticide resistance in mosquitoes—Baseline for data for a large-scale field trial in southern Mexico. *Proc. 2nd Internat. Conf. Insect Pests in the Urban Environment*, ed. K. B. Wildey. BPCC Wheatons Ltd, Exeter, UK, 1996, pp. 401–11.
12. Tomlin, C. (ed.), *The Pesticide Manual*. British Crop Protection Council & the Royal Society of Chemistry, Crop Protection Publications, 1994, pp. xxviii.